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VETERINARY JOURNAL

Editor:
FREDERICK HOBDAY, C.M.G., F.R.C.V.S., F.R.S.E.,
HONORARY VETERINARY SURGEON TO HIS MAJESTY THE KING,
OFFICIER DU MÉRITE AGRICOLE (FRANCE),
CAVALIERE DEI SS. MAURIZIO E LAZZARO (ITALY),
HONORARY MEMBER OF THE AMERICAN VETERINARY ASSOCIATION,
PRINCIPAL OF THE ROYAL VETERINARY COLLEGE, LONDON.

Sub-Editor:
GLADSTONE MAYALL, M.R.C.V.S.

AUGUST, 1931.

OUR TWO PRACTITIONER PRESIDENTS.

THIS year the practitioners of the profession may consider themselves to be doubly honoured, as the President of each of our ruling bodies has been selected from their ranks. Each has given ample proof of his respective interest in our professional work, and by a coincidence, too, they are residents in the same county.

Mr. G. P. Male, whom the Council of the Royal College of Veterinary Surgeons has elected to the highest honour the profession can confer, that of President of the College, has been a member of that body since 1919, having graduated from the London College in 1902. Commencing at Reading, he speedily built up a large practice. As a consultant his opinion is always valued, and as an all-round practitioner there is no one in the profession whose name is better known, especially where the subjects of dairying and clean milk are introduced. With a keen eye for a good hunter, his judgment has made him the owner of many winners, most of which have been ridden to victory by himself, and as he also carries the same level-headed judgment in the Council Chamber, the profession can rest assured that the Ship of State could not be guided by better hands.

In Lieut.-Col. Simpson the National Veterinary Medical Association has placed at its head the worthy son of a worthy father, for no one worked harder in the interests of the profession than did the late Mr. James Simpson. Colonel Simpson has given much evidence of his devotion to professional work, especially in connection with the Benevolent Society, and the Council of the R.C.V.S. (of which he has now been a prominent member for ten years) have honoured him with its confidence by election to the position of Treasurer.

The annual gathering of the National will be held at Norwich this month, and there can be no doubt but that with so popular a President the meeting will be a very great success.

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THE AGRICULTURAL RESEARCH COUNCIL AND THE VETERINARY PROFESSION.

IT is good news to read that at last an Agricultural Research Council has been formed, with the idea of encouraging the solution, by the way of research, of some of the various problems which stand in the way of progress in regard to agriculture.

As agriculture must of necessity include the farm animals (whose welfare is of equal importance to its prosperity as the study of cereals and other crops) one cannot but express surprise that there is no member of the veterinary profession included in the list of selected members. The omission is the more remarkable because the crisis which the country has just passed through in relation to the recent extensive outbreak of foot-and-mouth disease has given a further proof of the value of an efficient veterinary service. Had the powers-that-be not known how to grapple with such a contingency, or had not made full use of their powers, the country would have by now been in a similar predicament, in regard to this disease, to that in which several other countries find themselves.

Leaving out the Argentine and India, in each of which countries the disease is indigenous, the following table (comparing the number of outbreaks in various countries of Europe in 1930) will illustrate at a glance the superior position in this respect which Great Britain holds. This is almost, if not quite, entirely due to the scientific and sensible advice of its veterinary advisers :—

Month	Great Britain	France	Germany	Holland	Belgium
January	—	849	1,235	13	16
February	—	898	1,356	9	20
March	—	477	1,814	5	19
April	—	365	2,024	136	45
May...	—	307	2,541	1,569	109
June	—	283	3,097	6,117	117
July...	—	292	3,555	6,062	147
August	—	319	3,627	4,262	167
September	7	651	4,666	4,973	151
October	—	852	5,602	3,847	73
November	1	722	5,012	2,234	86
December	—	530	3,827	1,074	93

THE eradication of glanders, rabies, rinderpest, contagious pleuro-pneumonia, and a number of other diseases from Great Britain, is entirely due to veterinary research and its application; and, if further examples are needed, the millions of pounds which Schmidt's milk fever cure has saved for the farmers of all countries, and the benefit to sheep rearing which the pioneer work of Dalling, Gaiger and Russell Greig has done on the subject of lamb dysentery, with other things too numerous to mention, all freely given to the agricultural world without personal fee or reward, should have made the inclusion of veterinary scientists on an agricultural research council a *sine qua non*. Let us hope that the omission was not intentional and that there is some explanation which will do away with such an anomalous position as this want of thought has recently created.

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General Articles

COCCIDIOSIS IN CALVES.

By ANDREW ROBERTSON, M.B., Ch.B.

Lecturer and Milner Research Fellow, Department of Protozoology, London School of Hygiene and Tropical Medicine.

(Concluded from our last issue)

The Ætiological Agent.

The unfortunate confusion which has arisen as to the number of coccidian species occurring parasitically in cattle and other animals, may be due in part to the existence of races or strains of the same parasite, which may vary in size, and to a certain extent in shape. Then, again, it seems highly probable that the various species occurring in cattle, pigs, sheep, goats, and certain wild animals, such as the buffalo and the eland, are very closely related, and, indeed, in certain cases, as for example, *E. debliecki* of swine, and *E. zürni* of cattle, it is far from certain that a specific distinction does exist. Biester and Murray (1930) are of the opinion that the two species just mentioned cannot be differentiated on morphological grounds, and, further, they have proved experimentally that the *Eimeria* from calves is capable of infecting pigs.

The coccidian parasite of cattle was first discovered by Zürn (1878), and was named by Rivolta (1878) *Cytospermium zürni*. More recent work has shown that in reality it belongs to the genus *Eimeria*, and, accordingly, Rivolta's name becomes *Eimeria zürni*. Unfortunately, however, it would appear that neither Zürn nor Rivolta gave a clear description of this parasite, and to render the confusion greater, the term *E. zürni* was used to indicate the forms found both in cattle and in pigs (Wasielewski, 1896). Perroncito (1902) originated the term *Eimeria jalina* for the parasite found by him in swine, but, since later workers (Nieschulz, 1922, and Brumpt) have come to the conclusion that this organism was probably a Blastocyst, *Eimeria jalina* Perroncito, 1902, becomes *nomen nudum*. Douwes (1920) came to the conclusion that probably two distinct species were parasitic in pigs, and proposed (Douwes, 1921) for the smaller of the two forms the name *Eimeria debliecki*. Cauchemez (1921), who also was unable on a morphological basis to differentiate between the coccidia of swine and calves, created the specific name

Eimeria brumpti for the pig coccidium ; but the following year he agreed that both the terms *E. brumpti* and *E. suis* Nöller (1921) must become synonyms for *E. debliecki*. For a fuller discussion on the taxonomy of the swine coccidium, reference must be made to the work of Nieschulz (1922). Since then Biester and Murray (1930) have made a careful study of this special point as to whether, on a morphological basis, there was justification in separating the coccidial parasites of pigs into two species, and they concluded that up to the present there were insufficient grounds for such a procedure. This question of the nomenclature in the case of the pig coccidium, and the possible existence of two species, has been dealt with at some length, for an analogous situation has arisen with regard to the bovine forms.

That coccidiosis of cattle was a true clinical entity was first demonstrated in Switzerland by Zschokke (1892), Hess (1892), and Guillebeau (1893), the last of whom described the life cycle and mode of multiplication both in the large and small intestine. In his account, the oöcysts were comparable to those of *Eimeria stiedæ* in the rabbit, from the point of view of size, and because they possessed a micropyle. Züblin (1908) gave a description of the maturation of the oöcyst, noting the formation of the four sporocysts, each with two sporozoites. Thereafter, accounts have gradually accumulated from different parts of the world, and varying measurements have been supplied by practically every worker for the dimensions of the oöcysts. In 1918, Theobald Smith and Graybill drew attention to the disparity in the sizes sometimes shown by the oöcysts. The species they first encountered, and which was present in large numbers, was distinguished by a small oöcyst, usually elliptical, but occasionally ovoid or circular in outline. The oöcyst wall was thinner, had a double contour, and was of a uniform thickness. Measurements of thirty-six oöcysts gave the following results : Length, 16.4μ to 20.5μ, average, 18.6μ ; width, 13.1μ to 16.4μ, average, 14.8μ. On maturation it was found that four spherical sporoblasts gave rise to four elliptical sporocysts which were elongated and tapered at one end. At the narrower end the sporocyst wall was thickened to form a cap. There was neither oöcystic nor sporocystic residuum ("rest-korper") present. The sporocysts measured from 9.9μ to 11μ in length by 5.3μ to 5.7μ in width. The time estimated for the process of maturation at the midsummer temperature (in New Jersey) was about five days.

The second variety consisted of large ovoid oöcysts. The oöcyst wall was sometimes brownish in colour ; at other times it was colourless. The wall was thicker at the broader pole of the oöcyst,

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and thinned towards the narrower end. The dimensions given of two series of oöcysts were: Length 25.8μ to 41.8μ, by 17.2μ to 24.6μ wide; length, 28.7μ to 32.8μ, by 16.4μ to 20.5μ; average, 29.9μ long, by 19.9μ wide. There was no residual material present within the oöcyst in the larger species. The sporocysts were elongated, nearly elliptical in outline, and the sporocyst wall was thickened at one pole (the narrower) to form a cap-shaped protuberance. There was a large restkorper within the sporocyst. Measurements of eight spores were between 16.5μ and 17.1μ in length, by 7.2μ to 7.6μ in width.

In discussing the question as to whether these oöcysts may be representatives of two distinct species, the authors drew attention to the wide variations which were known to occur in the sizes of the oöcysts of different species of coccidia, and then state: "It may therefore be claimed that the inference that there were two species of coccidia in the calves is not called for. . . . The small ellipsoidal form was the numerically preponderating type, and in a few cases the one exclusively seen. . . . The presence of a restkorper in the large, and its absence in the small oöcyst is noteworthy. . . . . Seeing these two forms in the same field of the microscope, the observer is led to the conclusion that the burden of proof that they are variants of the same species must rest with the one who supports such a view" and, lastly, . . . "careful study of the sections did not enable us to distinguish between these species in the schizogonic cycle. This may have been due to the relative scarcity of the larger parasite in the material at hand."

The next important piece of work was that of Bruce (1921). In his cases the oöcysts varied in shape: spherical, elliptical, and ovoid forms being present. The larger oöcysts are always ovoid or elliptical, and the smaller oöcysts apparently showed a tendency to become spherical in course of time. The oöcyst wall varied in tint from colourless to light mouldy-brown. It would appear that many of the points of differentiation mentioned by Smith and Graybill between the two varieties of oöcysts, large and small, such as the thinning of the oöcyst wall at one pole in the ovoid forms, were present in Bruce's cases. The measurements were from 11.6μ to 43.1μ in length, and from 11.6μ to 27.8μ in width. The larger forms apparently were of commoner occurrence in the younger calves. There was no oöcystic residual material, but sporocystic residuum was present. The sporocystic residual mass (on the importance of of which undue stress has to be laid since it has been used as one of the points of differentiation between the two varieties), composed

of refractile granules, usually lay between the spores, but occasionally was in the form of scattered granules. The sporocysts varied in length from 6.6μ to 19.9μ, and in breadth from 4.5μ to 8.3μ. The coccidium described by Bruce covered in measurements the entire range of oöcysts (both varieties included) noted by Smith and Graybill, but in the presence of a sporocystic residuum, corresponded with the larger species only. For this coccidian parasite in cattle, Bruce created the specific name *Eimeria canadensis*.

Later, Yakimoff and Galouzo (1927) followed up the suggestion of Smith and Graybill that two species of coccidia might be present in calves, and, in brief, came to the conclusion that the smaller variety, characterised by the possession of spherical oöcysts, averaging 18μ in diameter, and showing no signs of a micropyle nor of residual material either in the oöcysts or the sporocysts, corresponded with *Eimeria zürni* Rivolta, 1878. The larger variety with its ovoid oöcyst, 31.5μ by 21.5μ on the average, which, too, had residual material in the sporocyst, they named *Eimeria smithi*. Yakimoff and Galouzo state that both forms showed a double contour to the oöcyst wall, but that in the oval form at the narrower end there is situated a micropyle, whereas in the smaller round form the position of the micropyle could not be discerned. Much stress also was laid on the fact that the smaller form tended to roundness in contrast to the ovoid form of the larger variety. If a specific distinction exists between the two varieties of coccidia found in cattle, it seems that Bruce's description covers all the points noted with regard to the larger ovoid variety, and if this larger variety is eventually proven to be a valid species, then the name proposed by Bruce, *viz.*, *Eimeria canadensis*, according to the law of priority would have to be considered as taking precedence to *Eimeria smithi* Yakimoff and Galouzo, 1927. It might be argued, on the other hand, that, as Bruce did not differentiate between the two species, the term *Eimeria canadensis* could not be taken as referring to either, and therefore should become a *nomen nudum*.

The coccidian parasite of the nylghai (*Boselaphus tragocamelus*, the wild cattle of India) found by Rastégaieff (1929) in an animal in the Zoological Institute at Petrograd, varied in length from 32.4μ to 41.4μ. This organism was named *Eimeria yakimovi* Rastégaieff, 1929. The data provided by the author was insufficient to differentiate it from the coccidia of bovines.

Triffitt (1924) described and figured oöcysts of an *Eimeria* parasitic in an eland, *Orias canna*, which was imported into the Zoological Gardens, London, from Durban, South Africa. In length they varied from 23.5μ to 34,μ and in width from 16.5μ to 20.μ There

was definite evidence of a micropyle. The sporocysts fell within a range of from 12μ to 16.5μ in the long axis, and 5.5μ to 6.5μ in the short axis. Sporocystic residual material was present, but in the oöcyst it was rarely found, and if there, was small in amount, usually consisting of a small indeterminate mass of granular material. Triffitt contrasted the measurements with those provided by other workers, and concluded that this variety in the eland constituted a distinct species for which was proposed the name *Eimeria canna*. This worker quoted Smith and Graybill (1918) as giving the oöcyst sizes (of bovine forms) as 18.6μ in length and 14.8μ in width, whereas, as noted above, the entire range quoted by these authors varied from 16.4μ to 41.8μ in length, and from 13.1μ to 24.6μ in width, which again covers the range of the forms in the eland. From the illustrations, the description and the measurements given by Triffitt, *Eimeria canna*, differs in no essential respect from the species in cattle.

Becker and Frye (1929), out of a series of forty calves, found three infected with coccidia, in two of which the oöcysts were so distinctly different from those in the third as to suggest the presence of two distinct species. In the two calves the oöcysts were ovoid or egg-shaped, broader at one end than at the other, with the oöcyst wall thinner at the narrower end. They measured 25μ to 32μ by 17μ to 22μ, average 29.7 by 20.2μ with the ratio average length ; average width, 1.47. They were of a salmon tint and had residual material within the sporocyst. In the third calf the oöcysts were predominantly ellipsoidal, and were colourless and inconspicuous. They measured from 20μ to 26μ by 13μ to 17μ, average 23.4μ to 15.9μ, with the ratio average length ; average width, 1.47. Becker and Frye compared the forms seen in this calf with the description given by Yakimoff and Galouzo of *Eimeria smithi*, and then bestowed on their organism the name *Eimeria ellipsoidalis*. The comparison may be tabulated as follows :—

	E. smithi, Yakimoff and Galouzo, 1927.	*E. ellipsoidalis*, Becker and and Frye, 1929.
Oöcystic residuum	Absent ...	Absent
Sporocystic residuum	Present ...	Present
Ratio $\frac{\text{Av. length}}{\text{Av. width}}$	1.47 ...	1.47
Oöcyst colour ...	Brownish ...	Colourless
Oöcyst wall ...	Thicker ...	Thinner
	Thins at narrower end	Same thickness throughout
Shape ...	Ovoid ...	Ellipsoidal
Size ...	Larger ...	Considerably smaller

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These authors state : " We have never seen *E. zürni*, but from the accounts of Jowett, Smith and Graybill, Yakimoff and Galouzo, and others, this form does not have a residual body inside the spore. Its tendency (*i.e.*, the tendency of *E. zürni*) toward the spherical shape is another difference."

When the larger, conspicuous form, which usually has a brownish tint of varying depth, is seen for the first time in the same field of the microscope as the smaller, less noticeable, clear and almost colourless form, the observer is inclined to agree with the statement of Smith and Graybill that the burden of proof must rest with those who consider the two varieties to be variants of the same species. They *look* so different. But, on more careful study, this is found not to be the case, and the onus of proof must be accepted by those who support the view that they are specifically distinct. While not denying the possibility that two species of *Eimera* (or more) may be true parasites of cattle and allied animals, for certainly evidence has been brought forward to lead to a suspicion that this may be the case, it has not yet been proven with sufficient clarity. The circumstances are very similar to those which have arisen with regard to coccidiosis in swine. Biester and Murray (1929 and 1930), after a very careful study, have come to much the same conclusion as that given above, in that they have been unable to convince themselves of the existence of more than one species of *Eimeria* (*viz.*, *Eimeria debliecki*) as the true causal agent of coccidiosis in swine, although forms exist which show wide morphological variations practically of the same kind as are found in the bovine form.

First, with regard to *Eimeria zürni* : although neither Zürn nor Rivolta gave what might now be considered an accurate definition of the specific characters, the name has been so long in use that this very usage implies its acceptance, and to make any change on the grounds of the inadequacy of the original description would simply increase the confusion. The name *Eimeria zürni* Rivolta, 1878, therefore, has the prior claim.

The next question that arises is whether the name *Eimeria canadensis* Bruce, 1921, applies to a species distinct from *E. zürni*. The essential points connected with Bruce's species have already been mentioned, and at the same time it was noted that Bruce's description covered practically all the features noted by Smith and Graybill when they suggested that two species might be present in cattle. Further, it was noted that in certain respects Bruce's description corresponded more with the larger variety (subsequently named *Eimeria smithi* Yakimoff and Galouzo) than with the smaller (accepted

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by Yakimoff and Galouzo as *Eimeria zürni*). From what can be gleaned from a study of the literature and observations on the oöcysts of cattle coccidia, it would appear that Bruce has failed to provide distinctions definite enough to render his species valid, and it is preferred to consider *Eimeria canadensis* Bruce, 1921, as a synonym for *Eimeria zürni* Rivolta, 1878. Bruce's work, however, was a valuable contribution in extending the knowledge of the morphological characters of *Eimeria zürni*.

The validity, or otherwise, of the second species created by Yakimoff and Galouzo, *viz.*, *Eimeria smithi*, for the larger forms found in cattle, is a matter much more difficult to decide. As has been indicated before, there is a superficial disparity in the appearances of the larger forms and the smaller forms, but when this disparity is analysed, it is found to be much more apparent than real. What appears to be one of the most important points against the formation of two species is the fact that the larger and smaller extremes, except in the matter of size, do not differ in any *essential* morphological detail, and, further, that every possible gradation occurs between the two extremes. Thus on size alone it is impossible to say when the larger variety ends and the smaller begins. In the matter of colour the same objection holds good. The larger forms undoubtedly do tend to have a more brownish shade, but, again, larger forms are found which are comparatively colourless, and, as before, the line of demarcation is not clean cut between the two, some having a deeper and others a less definite shade. Too great reliance cannot be placed on the shape of the oöcyst. There is a prevailing tendency throughout the whole range to adopt the ovoid shape, rather wider at one pole than at the other; but in the smaller varieties round forms are of quite common occurrence, and indeed, as was pointed out by Bruce, there is a tendency in these smaller ovoid forms to become rounder when kept for some little time. Since in the smaller forms the oöcyst wall is thinner, such a distortion would be much more liable to occur than in the larger forms with their much stouter covering. The presence of the micropyle, owing to the size, is much more easily discerned in the larger than in the smaller forms, but even there it can be made out if searched for carefully. The presence or absence of a restkorper cannot be accepted as a sufficiently diagnostic point on which to base the formation of a species. It is agreed that oöcystic residuum is at a minimum, and at the most is represented by a few vague indeterminate granules. Sporocystic residuum has been stated to occur in the larger variety, but not in the smaller. In this connection the writer has been faced with the same difficulties

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as before to determine where one variety began and the other ended; for in some of the larger forms sporocystic residuum might be so small in amount as to be scarcely demonstrable, and, instead of being aggregated into a definite restkorper, is scattered in the form of granules of varying size throughout the sporocyst. In numbers of the smaller forms a certain amount of residual material could be made out, but, again, as it was more frequently scattered, and because of the colourless character of the oöcyst as a whole, it was much less evident. The fact that, say, in one animal larger forms only may be found, whereas in another the small forms may preponderate, is not sufficient to determine this question. Until, therefore, further and much more convincing proof is brought forward, *Eimeria smithi* Yakimoff and Galouzo, 1927, cannot be accepted as a valid species, and the name, for the present at least, should become a synonym for *Eimeria zürni*.

Of the parasite found by Rastégaieff (1929) in the nylghai, and of which a very meagre description was given, little can be said. So far as can be determined, it did not differ from the larger forms of *Eimeria zürni*, except that it occurred in wild Indian cattle instead of the domestic variety. The parasite in the eland, *Orias canna*, for which Triffitt (1924) created the species *Eimeria canna*, falls in much the same category as the foregoing in respect of the fact that it did not show any divergence morphologically from *Eimeria zürni*, but was merely found in a different species of host. Since the hosts of these two species are so closely allied to domestic cattle, and since the creators of the species in question have failed to exclude the possibility of infection with *Eimeria zürni*, unless additional support is brought forward both *Eimeria yakimovi* Rastégaieff, 1929, and *Eimeria canna* Triffitt, 1924, should be considered as synonyms for *E. zürni*.

The forms comprised in *Eimeria ellipsoidalis* Becker and Frye, 1929, seem to correspond with the intermediate forms of *Eimeria zürni*, and while these authors compared their forms (and, as will be seen by reference to the table above, the comparison was a very close one) with the larger forms of *E. zürni* (the *E. smithi* of Yakimoff and Galouzo), no differentiation was attempted between their species and the smaller and intermediate forms except that comprised in the remark, also quoted above, that *E. zürni* does not have a residual body inside the spore, and that its tendency toward a spherically-shaped oöcyst was another difference. The conclusion arrived at is that Becker and Frye likewise have failed to prove a specific distinction between *E. ellipsoidalis* and *E. zürni*, and accordingly their name lapses into synonymity.

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Recently, Tubangui (1931) has carried out a survey of the domestic animals in the Philippine Islands for coccidiosis, his attention having been drawn, in the first instance, to cases usually occurring in December and January of bloody enteritis in young calves belonging to the dairy herd of the College of Agriculture, University of the Philippines. In addition to the smaller and larger forms, for which he accepts the names *Eimeria zürni* and *Eimeria Smithi* respectively, this observer described a third species occurring in association with *E. smithi* in the fæces of a bull, for which he created the specific name *Eimeria bukidnonensis*. The oöcysts were yellowish to darkish-brown, and were uniformly pyriform. They measured 46.8μ to 50.4μ by 33.3μ to 37.8μ. The oöcyst wall showed radial striations, and was about 2μ thick, except at the micropyle end, where it was very thin. The micropyle was conspicuous, about 4μ wide. The sporocysts were lemon shaped, and 14.4μ to 21.6μ by 9.0μ to 11.7μ in size. Neither definite oöcystic nor sporocystic residuum was present. In this observer's opinion the only species to which it bore some resemblance was *Eimeria ekdysios* Triffitt, 1928, found in a millipede. Whether or not *E. bukidnonensis* can be accepted as a valid species must depend on future confirmatory evidence.

The accompanying table of oöcyst measurements has been copied in the first instance from Yakimoff and Galouzo (1927), and a few additions have been made.

Worker.	Year.	Country.	Shape.	Length.	Breadth.	Diameter.
Zschokke ...	1892	Switzerland	Round	—	—	18–26
Hess ...	1892	do.	Round	—	—	—
Guillebeau	1898	do.	Round ; Egg-shaped	30	20	—
Züblin ...	1908	do.	Oval	12–25	10–20	—
			(seldom)	30–35	20	—
			Round	15	12	—
Galli-Valerio	1917	do.	Round	—	—	10–12
			Oval	12	8	—
Storch ...	1905	Germany	Round	—	—	13–16
			Oval	14–25	12–18	—
Müller	1914	do.	Round	—	—	12–27
			Oval	—	—	—
Otten ...	1922	do	Egg-shaped, broad oval round	15.2–43.7	14.2–29.6	—
			Average	29	20.7	—
v. Nederveen	1919	Holland	Round, Egg-shaped	18–21	15–18	—
de Blieck and Douwes	1920	do.	Round	—	—	12–16
			Egg-shaped	26—28	20–22	—
Krediet ...	1924	do.	Round	—	—	13–16
			Egg-shaped	14–34	13–19	—

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Worker.	Year.	Country.	Shape.	Length.	Breadth.	Diameter.
Ducloux ...	1905	North Africa	Slightly ovoid	30	20	—
Montgomery	1910	East Africa	Ovoid	14–20	12–18	—
			Average	17	15	—
Jowett ...	1911	South Africa	Round, sub-spherical			
			Smallest	14.4	12.8	—
			Largest	27.2	20.8	—
Degoix ...	1904	France	Oval	18–25	13	—
Marotel ...	1925	do.	Ellipsoidal	18–25	13–16	—
Bates ...	1915	Panama	—	60	40	—
Smith and Graybill	1918	U.S.A.	Round	13.1–28.7	12.3–20.5	—
			Average	18.6	14.8	—
			Egg-shaped	25.8–41.8	16.4–24.6	—
			Average	20.9	19.9	—
Craig ...	1919	do.	Round	16–18	14–16	—
			Smallest forms oval (occasionally round)	12–14	12	—
Davis and Reich ...	1924	do.	Ovoid	24–34	17–21	—
Roderick ...	1928	do.	Ovoid	13.7–19.8	12–18.3	—
Becker and Frye	1929	do.	Ovoid or Egg-shaped	25–32	17–22	—
			Average	29.7	20.2	—
			Ellipsoidal	20–26	13–17	—
			Average	23.4	15.9	—
Bruce ...	1921	Canada	Round, oval	16.6–43.1	11.6–27.8	—
Schein ...	1921	Annam	—	16–23	12.5–17	—
Wir ...	1926	Russia	Egg-shaped	25.2–32.4	14.8–28	—
Schein ...	1921	Annam	—	16–23	12.5–17	—
			Average	31.5	21.6	—
			Round	—	—	15.3–19.1
			Average	—	—	17.1
Yakimoff and Galouzo	1927	do.	(*E. zurni* variety) round average	—	—	18
			(*E. smithi* variety) ovoid average	31.5	21.5	—
Rastégaieff	1929	do.	(In nylghai) average	32.5	29	—
	1929	do.	(in bison)	16–29	14–20	—
Triffitt ...	1924	Great Britain	Oval (in eland)	23.5–34	16.5–20	—

Morphologically no distinction could be drawn between the forms found in Honduras and those in England, except that in one of the London calves there was a sharper dividing line between the two varieties, the larger brownish and the smaller colourless, of oöcysts. The prevailing shape was ovoid, with one end rather broader

than the other, but round forms and more sharply defined oval forms also were present. The sizes of the oöcysts varied from about 15μ to 35μ in length, and 10.5μ to 24μ in width, but it must be admitted that, as no prolonged search was made for oöcysts exhibiting extremes of size, the range was probably wider than the figures given. The majority of oöcysts had lengths between 17μ and 20μ. The oöcyst wall, which in by far the greatest number is colourless, varies in thickness in proportion to the size of the oöcyst. In the smaller forms

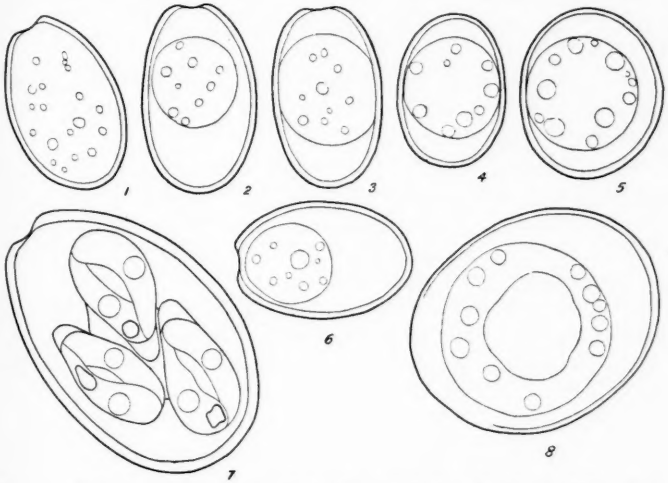

FIG. 1.—*Eimeria zürni* Rivolta, 1878. Camera lucida drawings of the oöcysts at a magnification of 1,520 diameters approx. Nos. 1, 2, 3, and 6 forms fixed in formol saline, oval in outline and showing the micropyle at one end. In No. 1 the contents had not yet contracted into a spherical mass. Nos. 4 and 5 were unfixed forms, and were rounder in outline. The micropyle could not be made out. No. 7 shows one of the larger forms after maturation. The micropyle is sharply defined, and in each of the three sporocysts visible (the fourth lay underneath the others) a mass of sporocystic residuum could be seen along with the two sporozoites. No. 8 is one of the larger oöcysts with a tendency towards a rounder outline.

it was probably well under 1μ, whereas in some of the larger it must have been close on 1.5—accurate measurements of the thickness of such a curved structure are very difficult to obtain.

A micropyle was present at the narrower end. This micropylar indentation, or thinning in the wall, was found throughout the entire range of oöcysts, large and small, but it became progressively more difficult to discern the smaller the size of the oöcyst, or the greater their tendency to roundness. Quantities of the fæces had been fixed for preservation, and this procedure resulted in the micropyle

becoming more obvious, sometimes even appearing as an indentation of no great depth. Oöcystic residual material was practically absent, but occasionally a few indefinite granules could be made out. When fully developed the oöcyst contained the four characteristically shaped sporocysts, ovoid in outline, with one end a little narrower and more pointed than the other. At the sharper end there was also a distinct cap or protuberance. Sporocystic residuum varied in quantity, and also in shape and appearance, and, again, was more prominent in the larger variety. Sometimes it was in the form of a distinct residual mass, sometimes it seemed to take the form of droplets of fatty material, or, again, might be scanty and in the form of small scattered granules. The sporocysts varied, as also did the contained sporozoites, within fairly wide limits of size, but were proportional to the size of the oöcyst.

No accurate observations were made on the time required in Honduras for the completion of the process of maturation. At the prevailing temperature, which was about 80° F., a fair proportion of the oöcysts had completed their development in five days, but it was noticed that if the fæces were too moist from the admixture of water, the process seemed to be delayed. Various methods have been recommended for the maturation of the oöcysts (cultivation as some workers prefer to call it). The simplest, and at the same time the most efficacious, would appear to be the following : First emulsify the fæces in water, and then either strain through gauze sieves of varying mesh, or employ one of the methods of washing and concentration. Finally, to the fæcal emulsion add a small quantity of a dilute solution of potassium bichromate. This is sufficient to inhibit or to hold in check the growth of moulds, and at the same time does not interfere with the process within the oöcysts.

Endogenous Cycle.

It is unnecessary to do more than briefly mention the schizogonic cycle, for, so far as can be made out, there are no gross departures from what is usually found in intestinal infections of animals with parasites of the genus *Eimeria*. The most important feature is that the sites of election for the parasite to undergo its development are the large intestine and, to a very much lesser extent, the small gut. Secondly, the development does not, as a rule, take place in the superficial part of the mucosa, but deep down, almost on the surface of the submucous layer. Next, it is of great practical importance to realise that unless the infection is a particularly heavy one the chances of finding the developing stages are very low, and search for the forms in the tissues of animals known to be infected is often unsuccessful.

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A further and subsidiary point is that one form or other of development seems to preponderate at any given time during the course of the disease. Probably at the beginning of the infection the asexual cycle is more prevalent, whereas later on the sexual forms are more frequently encountered. Smith and Graybill (1918), for example, in their preparations found the asexual forms in abundance, while gametocytes were relatively scanty. In the tissues from infected calves in Honduras, the sexual forms appeared almost exclusively. Of five calves, the intestines of which were obtained from the abattoir in London, and of which four were known to be infected from the finding of oöcysts in the fæcal material, none had a sufficiently heavy infection to permit of the demonstration of the endogenous cycle.

According to Smith and Graybill, the earliest stage is roundish or elliptical in outline, and on the average, measures about 6μ in diameter. The nucleus at this stage consists of a clearly defined deeply staining karyosome surrounded by a clearer zone, which in turn is delimited from the cytoplasmic part by the rather poorly defined nuclear membrane. The fully matured schizont measures from 10μ to 15μ in length, by 9μ to 10μ in width (Marotel, 1925). The number of merozoites varies in each mature schizont from 13 to 26 (Smith and Graybill), or 15 to 30 (Marotel). No definite number can be given for the forms in Honduranian cattle, since in no instance could it be ensured that the entire schizont was present in the section of gut. Marotel gave the length of the merozoites as 5μ to 6μ, with a diameter in cross section of about 1.5μ. The writer is in agreement with this last figure, but considers that the individual merozoites may be longer, probably 9μ or even a little more.

The developing microgametocytes can usually be differentiated from the corresponding macrogametocytes fairly early on in the process. The male tends to be larger in size, and its cytoplasm is less dense, may be vacuolated, and stains irregularly and less deeply. The nucleus of the male by a series of successive divisions gives rise to what Smith and Graybill referred to as coccus-like bodies, which tend to arrange themselves around the periphery of the parent cell. When fully matured the microgametes are fine thread-like bodies (unlike the comma shape of the microgametes of *Eimeria perforans* or *E. stiedæ* of the rabbit), and have the same thickness throughout their length with the exception of a small round granule at one end. They stain most sharply with hæmatoxylin (*i.e.*, the basic stain). Their number varies: Marotel estimated the number in each microgam etocyte as between one and two hundred.

The female gametocyte is easily differentiated by its possession

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of a number of metachrome granules. These granules are comparatively large in size, stain fairly deeply with hæmatoxylin, and are arranged over the periphery of the cell. Thus when the macrogametocyte is seen in cross section it appears to have a complete ring of granules. Sometimes in the interior of the macrogametocyte round granules can be made out, fairly sharply defined as to their

FIG. 2.—Photomicrograph at a magnification of × 500 approx. The part shown is from a section of the large intestine of a calf and illustrates the deeper layers of the mucosa close down to the musculares mucosæ. In the blind end of the gland can be seen a characteristic nidus of coccidian parasites. Note the slight but definite increase of fibrous tissue around the group of parasites, and the infiltration of the inter-glandular stroma. The goblet cells in the gland itself are in a state of hyper-activity, while some debris has accumulated in the lumen of the gland.

margins, and giving an eosinophile staining reaction. It is possible that these granules may be the precursors of the large round granules or globules seen in the cytoplasm of the freshly passed oöcyst. Occasionally undifferentiated oöcysts are found which have not yet escaped from the containing cell, or may still be lying in the gland lumen.

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PATHOLOGY.

Considering the length of time this disease has been known to veterinary science, it is remarkable how few observations have appeared in the literature dealing with the pathology. It is especially of importance that the remoter effects, that is to say the results of

FIG. 3.—Photomicrograph of the same section shown in Fig. 2, but at a higher magnification (× 750 approx.) to show the parasites. In the three female gametocytes on the left the ring of basophile staining granules is clearly seen round the periphery of each parasite, while in the interior the somewhat larger acidophile granules or globules can be made out. The fainter, more irregularly staining male gametocytes (on the right) contain the thread-like microgametes. Note the thickening of the fibrous tissue round the nidus of parasites.

the invasion of the tissue cells and their destruction, and the attempts, whether adequate or not, at repair and tissue replacement, should be carefully studied with a view to determining the degree of impairment in function permanently left in the intestine.

Contrary to expectation, when post-mortem examinations were carried out on calves which had died as a result of acute coccidiosis,

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on macroscopical examination the intestine as a whole showed an entire absence of any signs of disease except possibly that, in the majority of instances, it seemed a little paler than normal. There was no apparent thickening, nor did the peritoneal covering exhibit any abnormality. Even when the lumen of the gut was laid open, no patches of discoloration could be made out. The patches of coccidiosis gave no indication of their presence, and, as the distribution throughout the gut is not uniform, it was purely fortuitous whether

FIG. 4.—Photomicrograph at a magnification of approx. × 500 of the deeper layers of the mucosa, showing a nidus of parasites (mostly female gametocytes) bulging out the end of one of the glands of Lieberkühn. The increase in the inter-glandular stroma and the cellular infiltration of the stroma are noticeable.

or not a heavily infected area was selected for fixation and sectioning. Even the congestion and punctiform hæmorrhages noted by Smith and Graybill were absent, nor were the small areas of necrosis seen by these two workers found in the Puerto Arturo calves. Yakimoff (1926) made note of the hyperæmic condition of the intestine, which was more marked in the large gut, and of the rectal ulceration which was occasionally present. It seems that the most important feature to be searched for by the naked eye are the plaques (as described by Ducloux, 1905, and others) of a greyish-brown or yellowish tint, which project very slightly above the level of the mucosa. These

raised areas are probably due to a local aggregation of the parasites with œdema and necrosis, followed in some instances by ulceration. Degoix (1904) described a similar plaque formation, but suggested that the superficial layer was composed of mucus or mucoid material which gave the yellowish colour, and that when this covering was removed, the underlying mucosa might be even paler than that of the surrounding area. Sometimes the mucosa beneath these plaques showed signs of ulceration.

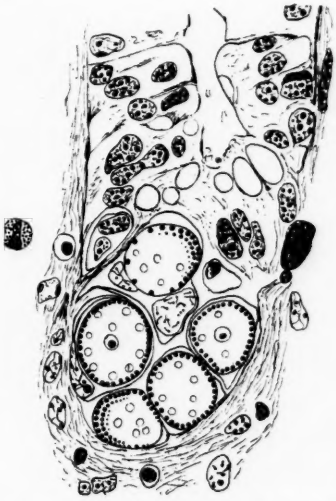

FIG. 5.—Section of the large intestine of a calf drawn with the camera lucida. In the blind end of the tubule or gland of Lieberkühn six parasites can be made out which have destroyed, either by living in or by pressure exerted on the cells, the epithelium. Five of these parasites are female gametocytes with the deeply-staining peripheral ring of granules, and in the interior the slightly larger acidophile granules. In the centre of the nidus is a micro-gametocyte with its contained thread-like micro-gametes. The condensation of the fibrous tissue around the parasites has been indicated as also has the increased activity on the part of the glandular elements.

Microscopically it is found that the parasites have invaded the epithelium of the glands of Lieberkühn. The infected glands tend to be shortened, and their orifices sometimes are irregular or deformed, and may be filled with epithelial debris. This, however, is not common, for it is usually only in the blind end of the tubule close down to, and nearly in apposition with, the musculares mucosæ, which is dilated and more or less occupied by the coccidia, that definite changes

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have taken place. The coccidia in their intracellular development have destroyed and largely replaced the tissue cells. The remainder of the glandular epithelium is progressively less subject to invasion the nearer it approaches the surface.

As a result of this destruction of the superficial layer of the mucosa, hæmorrhages take place into the lumen of the gland. These individually are small in amount, but since the infected glands may be very numerous, the total is considerable. Thus, as was pointed out by

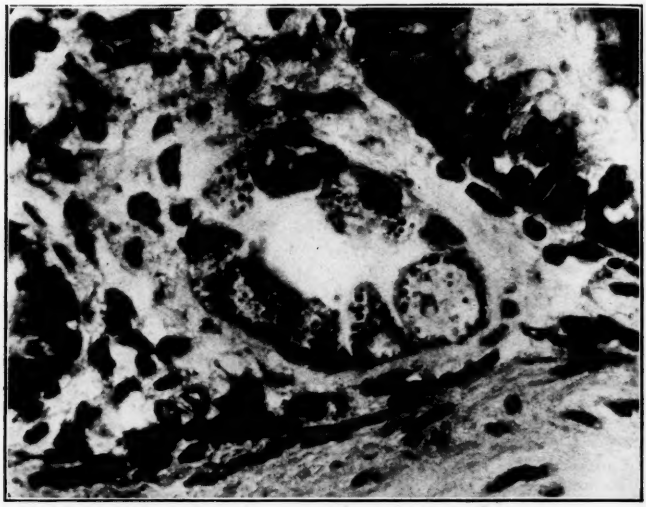

FIG. 6.—Photo-micrograph at a magnification of approx. × 825. At the bottom of the photograph are the musculares mucosæ of the large intestine, and in the centre, immediately above, is an oval structure which was originally the end of one of the glands of Lieberkühn, but is now occupied by coccidia. All the forms seen are female gametocytes, with the exception of the one at the top of the oval which is a male. In this the microgametes are arranged so densely that they appear to form almost a continuous ring. The fibrous tissue is increased in amount, and is more compact in formation around the group of parasites.

Smith and Graybill, the blood appearing in the fæces is not the result of a single massive hæmorrhage or several such hæmorrhages, but is rather the summation of a very large number of minute extravasations detectable post-mortem only with the aid of the microscope.

There is marked congestion of the gut as a whole. This is not confined to the mucosa, but is also present in the deeper layers, especially, as would be expected, in the submucosa. In the mucosa there was evidence of increased glandular activity, the mucus-

secreting goblet cells being particularly noticeable. This might be due to the extra amount of blood in the organ, or might be the direct result of the stimulation provided by the coccidia. This circumstance explains the presence of the huge quantities of mucus in the fæces of infected calves.

The interglandular stroma, apart from the local lesions, is increased in amount, and appears to be a little œdematous. It is also infiltrated

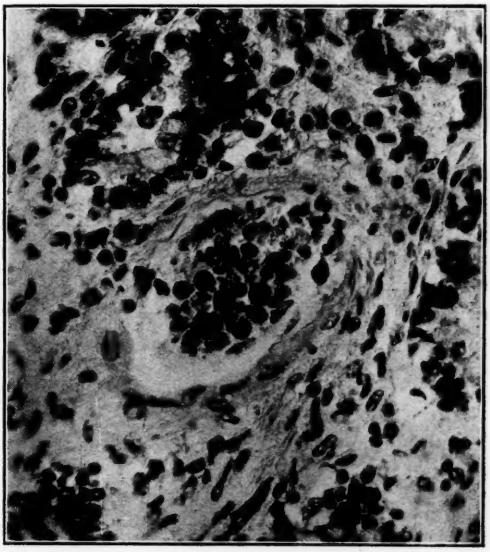

FIG. 7.—Photo-micrograph at a magnification of × 500 approx. The area shown is from the deeper layers of the mucosa, and illustrates the earlier stages in the process of repair. In the centre is a mass of blood clot which has been invaded by cells, chiefly eosinophile leucocytes with an occasional reticulo-endothelial cell. Surrounding this is a zone which exhibits an increased activity on the part of the fibrous tissue as evidenced by the larger proportion of young fibroblasts, and by the presence of reticular cells.

with cells; in this respect the writer confirms the work of Degoix. There is an increase in the number of reticulo-endothelial cells (plasmatocytes), and plasma cells are also found. Both these types of cells are in all parts of the mucosa, but are more prevalent in the deeper and middle parts than in the superficial zone.

One of the most noticeable features in the mucosa is the infiltration

with eosinophiles. This was very marked in the tissues from Honduranian calves, but, at the same time, it was thought that it might be an accidental occurrence or due to some local factor. The same condition was present in the intestines of calves killed in England, though in less degree. It is possible that a certain number of eosinophiles may find their way into the interglandular stroma of un-

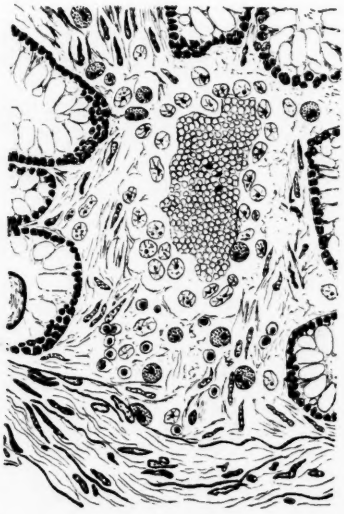

FIG. 8.—Camera lucida drawing of a section through the deeper layers of the mucosa of the large intestine. This illustrates the earlier stages in the reparative process. Below are seen the musculares mucosæ, and towards the centre a mass of red blood corpuscles which has resulted from a hæmorrhage into the lumen of one of the glands of Lieberkühn. By comparison with the other glands present in the drawing, it will be seen that all traces of glandular structure have been lost in the diseased area. Surrounding the mass of red cells is a zone of reticular elements, and again outside this there is marked activity on the part of the fibroblastic cells. Eosinophile leucocytes are found scattered throughout the stroma.

infected calves, but taken into account with the fact discovered by Yakimoff and Markoff-Petraschewsky that the blood of infected calves exhibits a definite eosinophilia, and also the numbers of these cells present in the tissues, it seems highly probable that this eosinophile infiltration represents a definite response on the part of the host to the parasitic invasion.

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The part of the gland, *i.e.*, the base, which is serving as a lodgment for the parasites, is dilated, and larger in diameter than the remainder of the gland or the bases of other non-infected glands. The connective tissue immediately surrounding the base of the infected gland is denser and frequently shows signs of a slight fibro-blastic reaction. It is possible that this has resulted from a condensation, hypertrophy, and proliferation of the previously existing fibrous tissue.

After the parasites have reached maturity and have ruptured out of the cells, the lumen of the blind end of the acinus is filled with a mass of blood cells or clot. This may be considered as the first

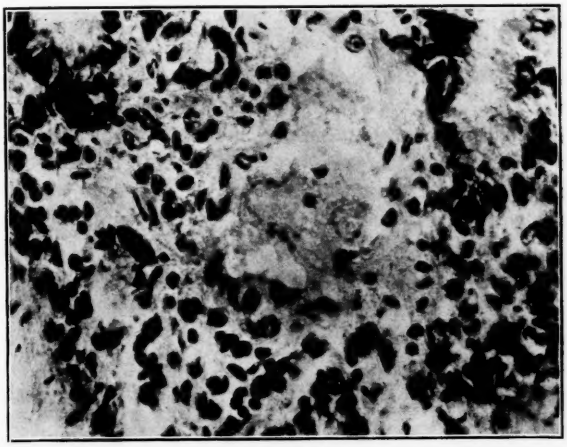

FIG. 9.—Photo-micrograph at a magnification of × 500 approx. to show a rather later stage of repair. The central blood clot has been partially absorbed ; the red cells have lost their outlines, and all that is left is a pink staining mass of practically homogeneous material surrounded by reticular cells. The cellular infiltration in the surrounding stroma is well seen.

stage of the reparative process. All traces of the epithelium or the basement membrane are lost. The hæmorrhagic area, however, is sharply defined from the looser areolar tissue round about ; firstly, by the remains of the rather denser zone of fibrous tissue mentioned above, and by the very definite area of tissue reaction. This, in turn, consists of an active multiplication of reticulo-endothelial cells, especially those of a reticular character, which arrange themselves in annular fashion around the mass of blood cells. Immediately surrounding the lesion there is marked activity on the part of the fibrous tissue-forming elements, as is evidenced by the much larger

number of young fibroblasts present in this as compared with more normal portions of the gut. The eosinophile infiltration, too, is more marked in the neighbourhood of these lesions, and not infrequently there may be some evidence of small round-celled infiltration closer to the musculares mucosæ.

The reparative process apparently is a gradual one. In the central blood clot the corpuscles lose their clear-cut outline, and a homogeneous, pink-staining mass results, which in time is found to contain numbers of eosinophile leucocytes. Sometimes the eosinophiles are so numerous that the mass seems to be largely composed of these cells. The homogeneous debris resulting from the breaking down of the red cells is absorbed, and the reticular elements penetrate gradually towards the centre. Finally, practically no signs are left of the destroyed part of the gland beyond young fibrous tissue and a quantity of reticular cells. The exact character of these so-called reticular cells is somewhat difficult to determine; they may give rise to the young fibroblasts, but this seems to be very doubtful. On the other hand, their function may be primarily absorptive to remove the mass of blood cells.

In confirmation of the observation made by Smith and Graybill, it may be said that forms of the parasite are frequently encountered actually lying in the interstitial tissue. In this situation both developing forms, oöcysts with fully formed oöcyst wall and practically mature male and female gametocytes, were found, but never schizonts. No ostensible reason can be adduced to account for this absence of schizonts beyond the fact that forms belonging to the schizogonic cycle were very scanty in the material available. The type of cell which these aberrant parasites were inhabiting was rather difficult to diagnose, but there seems little doubt they were in the nature of reticulo-endothelial structures. On several occasions groups of coccidia were found in situations which were removed from the glandular elements. No degree of certainty could be reached as to what tissue elements were being parasitised in these instances. The possibility was considered, however, that perhaps the coccidia had penetrated into one of the smaller blood capillaries, or even more likely into one of the lesser lymph channels, and therein had attacked the lining endothelium. This, however, is purely a matter of conjecture. Groups of merozoites, possibly the whole mature schizont, were met with lying free in the lumina of uninfected glands right at the base.

It was not possible to carry the observations on the process of repair beyond the stage indicated, but there seems to be no reason

to suppose that anything results beyond the replacement of the glandular structure with fibrous tissue. It has already been emphasised that unless the infection in the calf is a particularly heavy one, the finding of the forms in the tissues, considering the relatively huge area occupied by the mucosa of the large intestine as a whole, is highly difficult. Indeed, it might almost be said that, if the infection is not sufficiently severe to cause comparatively serious clinical symptoms, the chances of finding tissue lesions are not particularly good. But, when the infection is a heavy one, the amount of tissue which may be destroyed and replaced by scar tissue is very large indeed. What effect this will have on the functioning capabilities of the organ can only be surmised, but it seems a likely hypothesis that many of the calves, though tided over the acute stage, may never completely recover from the effects of the attack, the fever, and more especially the intense anæmia; or, secondly, from the interference with intestinal function.

The immediate cause of the death of the animal varies according to circumstances. Frank (1926), for example, suggested that the symptoms point to septic infection as the probable cause of the fatal ending, since the coccidia themselves do not cause inflammatory reactions, but simply open the way for bacterial invasion. From the work of Montgomery, Balfour, Stevenson, Schultz, Cerruti, and others, it seems a reasonable conclusion to draw that while coccidiosis may render animals more subject to infection with other diseases, certain other diseases, such as rinderpest, may increase the susceptibility to severe coccidiosis. Another intercurrent condition which frequently ushers in a fatal termination is pneumonia.

The pathological changes in the body, apart from the lesions in the gut, are chiefly those of enlargement and cloudy swelling of the soft organs (Larson, 1929). Tscherniak (1927) mentions that histological examination of bovine intestines shows that there may be destruction of the wall right down to the serous coat, accompanied by the appearance of giant cells in the zonal lymph glands of the mesentery. Such an extensive ulceration cannot be due to the coccidiosis *per se*, and local secondary invasion must have taken place to produce these changes. Züblin (1908) also thought that in his cases septic infection was the probable cause of death, and suggested that the mortality-rate in a herd might depend more on the presence of septic organisms and their relative degree of virulence. Some experimental evidence on these lines has been provided by Carré (1928), who fed cultures of staphylococcus to lambs with coccidiosis. The results, however, did not appear to be very definite.

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In the Honduranian calves the tissue changes in the organs were such as might be found in any acute disease, especially one showing such an intense degree of anæmia. In the livers of these animals there was evidence, in the separation of the columns of liver cells, of slight œdema. The parenchyma cells showed signs of degenerative changes and cloudy swelling.

In view of the mention made by Smith and Graybill of the discovery of a sclerotic condition in the kidney, rather more attention was paid to the study of that organ, with the result that in the majority of instances, changes were found to have taken place. The findings may be summarised briefly: The capsule did not strip readily. On microscopical examination there was marked congestion of the organ as a whole, and petechial hæmorrhages had occurred into the interstitial tissue. The congestion was most intense, and the hæmorrhages most numerous in the neighbourhood of the straight tubules. Occasional patches of intense congestion and hæmorrhage were found around the convoluted tubules, but these patches did not involve such a wide area nor were they so constantly present as those in the straight tubule zone.

The glomerular tufts were swollen and œdematous in many instances, while one or two showed signs of the prevailing congestion. The epithelium lining Bowman's capsule was swollen and degenerate. In the convoluted tubules the epithelium showed cloudy swelling to a considerable degree, the cell margins had lost their sharp outline, and the nuclei, too, did not stain so crisply. Casts were present in a large number of the tubules, and were of a finely granular character. In the straight tubules the degenerative changes were even more noticeable. The cells had lost their outlines, and sometimes the nuclei had disappeared. Casts were frequent, but were more coarsely granular than those in the convoluted tubules. Sometimes it appeared as if small hæmorrhages had occurred into the lumina of the tubules, but, so far as the information was available, no signs of hæmoglobinuria had been noted. The interstitial connective tissue throughout the organ showed signs of proliferation.

Treatment.

Large numbers of drugs have been tried in the treatment of acute coccidiosis in cattle and in other animals, but so far nothing appears to have been discovered which is not open to objection of some kind. The main reasons militating against their use would appear to be: firstly, the cost entailed in the provision of the requisite medicaments; secondly, the difficulties encountered in mass administration; and, thirdly, no drug has yet been discovered with a specific action on the

coccidiosis. The various types of drugs may conveniently be grouped under a series of headings.

Laxatives.—Frank (1926), among other measures, mentioned the use of laxatives.

Sedatives.—Under this head can be grouped the various substances which may have a soothing effect on the irritated intestinal mucosa. The insoluble bismuth salts may be included in this category as well as the mineral oils used by certain veterinarians (*e.g.*, Newson and Cross), as vehicles for other preparations.

Intestinal Antiseptics.—This group is by far the largest, and comprises a wide range of preparations. Thymol (10 per cent.) was recommended by Cerruti (1929), and also in doses of 15 grams per day by Sanlorenzo (1917). In coccidiosis of dogs, Wood (1926) administered eucalyptus oil (3 minims) in cod-liver oil (30 minims) thrice daily. Formalin, in half to one ounce daily doses, was tried by Frank (1926) in bovine coccidiosis, and by Krijgsman (1929) in the disease of poultry. Probably the most popular drug of all is creoline or cresol. This has been used in the avian form of the disease by Krijgsman ; in the bovine variety by Yakimoff (1927) ; Frank (1926), and others. Krijgsman found that a useful method of administration in the case of rabbits was to give the following mixture : creoline, 2.5 c.c. ; sodium bicarbonate, 4 grams ; syrup, 400 c.c. ; water, 2,000 c.c. ; aniseed, 4 drops. Of this, 75 c.c. were given daily, and the rabbits would drink this amount provided they were on a dry diet.

Salol has been used by Degoix (1904) for cattle, and by Wood (1926) for dogs (2.5 grain doses for pups ; 5 grain doses for older dogs, thrice daily). Yatren seems to have been favoured by a number of workers, among whom may be mentioned Krijgsman (in chicks), and Kum (1922) (in sheep), but the results have been disappointing. Naphthaline (Yakimoff, 1927) and benzo-naphthol (Degoix, 1904) have also been tried, but without much effect.

Astringents.—Various preparations have been used which exert different degrees of astringent action on the gut, and a certain amount of success has been claimed for their use. As, however, many such substances are given by the rectal route, they will be specified along with some others, under the next heading.

Rectal Injections.—Good results may be obtained (Frank, 1926) by injections of 1 per cent. aqueous solutions of alum or of tannic acid. Intestinal lavage was recommended by Degoix (1904). Perhaps the commonest substance used is tannic acid, or a combination of tannic and salicylic acids. Many of the intestinal disinfectants

already mentioned have been administered in this manner. Perhaps the most important of the rectal injections is ictargan, the use of which was suggested by Yakimoff (1927). This preparation, which contains about 30 per cent. silver, is a combination of that metal with ichthyol. It is of relatively low toxicity, and previously it had been used in a number of disease conditions in veterinary practice. It was given in the form of a solution of 1 gram in 1,000 c.c. of water (but without any sodium chloride) to adult cattle, and in proportionately smaller quantities to calves. Very favourable results were reported. Sulphur and iron sulphate by the mouth in a mucilaginous base were given by Marsh, while a number of workers have utilised iron sulphate by the rectal route for its astringent properties.

Tonics and Other Drugs.—Beyond the administration (by Frank) of strychnine sulphate in half-ounce doses, thrice daily, of a 1 per cent. solution, the writer has been unable to find records of the use of other tonics. No mention has been made of iron, arsenic, and antimony, and in this connection it seems probable that a combination of iron and arsenic might have a useful effect during the period of recovery from the severe anæmia, while certain organic arsenicals such as stovarsol by the oral route perhaps might influence the course of the disease.

Bayer 205 was tested, but with poor results, in bovine coccidiosis by Yakimoff (1927) following in this respect Warworuntu, who noted in Holland its beneficial effect on rabbits suffering from the disease. Quinine, in the form of various salts, but especially the sulphate, has been advocated in avian coccidiosis by Patterson (1926), and by Johnson (1926). Eriksen (1925) was unable to record any success in the avian form by the use of neoarsphenamine in doses of from 0.003 to 0.25 gram by intrapulmonary, intracardial, intravenous and subcutaneous administration. Nagonal (subcutaneous) and yatren (intramuscular) were tried on birds by Krijgsman (1929), but were of no avail.

Dietetic Measures and Care of the Sick Animals.—Considerable stress has been laid on the importance of these measures by veterinarians. With regard to the care of the sick animals the bulk of opinion would appear to favour their segregation in separate pens which are cleaned out daily and fresh bedding and foodstuffs supplied (Barnes and Brueckner, 1927). The sick animals should be disturbed as little as possible, for movement would seem to tend to increase the tenesmus, the hæmorrhage and the liability to fits. Dietetic measures (Degoix, Krijgsman, and others) should be directed towards supplying the most nutritious foods in the smallest compass. Milk has been recommended.

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Prophylaxis.

Prophylactic measures are by far the most important feature in the control of the disease, and if consideration is given to the various factors which enter into epidemic causation—for apart from the epidemics the disease is relatively unimportant—the actual methods will be obvious. The commonest cause of the epidemics is the close herding of numbers of non-tolerants along with carriers (tolerants). When such a combination of circumstances cannot be avoided, lot rotation should be adopted. That is to say, the herd should be allowed to remain for not longer than three or four days (assuming the maturation of the oöcyst to occupy five days) on the same localised area of pasture land, and ought not to return to that part until some time has elapsed, the actual length of which can only be determined by local conditions. Damp undoubtedly favours the dissemination, and, when possible, dryer ...lly pastures should be used. In areas where there is an annual outbreak among the calves, any measures which would tend to delay the onset would be advantageous, since it seems clear that the older the animal the less susceptible it becomes, and although it may contract the disease the effects will be much less serious.

Where animals have to be placed in confined spaces, such as concrete pens, cleanliness would appear to be the most important factor. Chemical antiseptics such as are known at present, and in the dilutions which ordinarily can be used, are of no use whatever in the destruction of the oöcysts. There is some divergence of opinion as to whether the severity of the disease is or is not dependent on the size of the infecting dose, but there is much more definite evidence in favour of the severer cases resulting from heavy initial infections, and, accordingly, every effort should be made to restrict the sources of infection to a minimum.

Summary and Conclusions.

Seasonal Incidence.—Coccidiosis in bovines is of commoner occurrence during the warmer months of the year, *i.e.* spring, summer, and to a much lesser extent early autumn.

Source of Infection.—The commonest mechanism whereby infection is introduced or is maintained in a herd is by carriers.

Immunity.—Evidence exists that immunity to infection increases with increasing age. An attack of the disease does not confer immunity except of the " premunitive " kind, which is dependent on the persistence within the body of the host of small numbers of the parasites.

Age Incidence.—Acute coccidiosis is essentially a disease of young animals. Older animals suffer less severely and are less prone to infection.

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Mortality.—Case mortality may be very high, and may vary up to 50 per cent. of the visibly affected animals. The mortality varies according to local circumstances, and is dependent on many factors, to all intents and purposes the same as enter into the causation of epidemics.

Intercurrent Diseases.—Pneumonia and nephritis have been mentioned as occurring along with coccidiosis. Certain diseases, such as rinderpest, may increase the susceptibility to bovine coccidiosis.

Epidemic Causation.—The chief factor causing coccidiosis to become epidemic is close herding, especially when non-tolerant animals are grouped along with carriers. Subsidiary factors are damp, such as is found in marshy pasture land, and temperatures sufficiently high to favour the rapid maturation of the oöcysts outside the body.

Symptoms.—The most characteristic symptom is the severe diarrhœa accompanied by the passage of blood and mucus. Infected animals tend to adopt a characteristic attitude with the back arched and head held forward. Anæmia is severe. Emaciation comes on rapidly. There may be an eosinophile leucocytosis. A degree of fever may be present.

Incubation Period.—Probably varies between six and twenty-one days.

Duration of the Disease.—In young animals the acute manifestations usually last up to about ten to twelve days.

Convalescence.—The period occupied by convalescence in the more severe cases is at least three months.

Cause of Death.—Secondary septic invasion, severe anæmia, pneumonia, etc., have been incriminated as the chief causes of the death of the infected animals.

Ætiological Agent.—Certain species, *viz.*, *Eimeria canadensis* Bruce, 1921; *Eimeria smithi* Yakimoff and Galouzo, 1927; *Eimeria yakimovi* Rastégaieff, 1929; *Eimeria canna* Triffitt, 1924, and *Eimeria ellipsoidalis* Becker and Frye, 1929, have been considered. In each instance the conclusion arrived at is that the specific identity distinct from *Eimeria zürni* Rivolta, 1878, has not been proven, and until such time as further and more definite evidence is available it is preferred to regard them as synonyms of *Eimeria zürni.*

The variations in the size and appearance of the oöcysts have been noted.

Maturation of the Oöcyst.—Five days are probably required for the formation of the sporocysts and sporozoites within the oöcyst.

Endogenous Cycle.—In an animal suffering from acute coccidiosis it is probable that schizogony preponderates at the beginning, whereas

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later on in the infection gametocytes are more commonly found in the epithelial cells of the large intestine. The large intestine is the site of election for the parasite to undergo its development; the lesser gut is also infected, but to a very much smaller extent.

Pathology.—The lesions in the intestine are found at the bases of the glands of Lieberkühn. As a result of the destruction of the epithelium, hæmorrhages take place into the gland lumina. The various stages of repair probably result in the formation of scar tissue. The other organs tend to show cloudy swelling, and in the kidney signs of nephritis are sometimes seen.

Treatment.—Various drugs which have been used in the treatment of the disease have been considered, but none so far appears to be entirely satisfactory.

Prophylaxis.—The most important feature in the prevention of the disease would appear to be the avoidance of close herding.

References.

Owing to the fact that the references dealing with coccidiosis in cattle have appeared in a very large number of publications, they are not readily accessible. The accompanying list, therefore, is far from complete. On the other hand, a certain number of papers have been included which, although dealing primarily with coccidiosis in animals other than cattle, may have a bearing on the question of bovine coccidiosis or coccidiosis in general. References marked (S) (following the author's name and the year) refer to sheep, (G)=goats, (P)=pigs, (R)=rabbits, (A)=birds; such other animals as are dealt with are named *in extenso*.

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TRICHOSTRONGYLUS AXEI (Cobbold, 1879, Raillet and Henry, 1909) and T. EXTENUATUS (Railliet, 1898, Ransom, 1907).

By G. B. PURVIS. M.R.C.V.S.
Federated Malay States.

G. Theiler, 1923 (1), mentions *T. axei*, but does not give *T. extenuatus* as one of its synonyms.

Le Roux, 1924 (2), states that the two are morphologically identical.

Yorke and Maplestone, 1926 (3), list these species separately ; the former as a parasite of equines, etc., and the latter as a parasite of cattle, sheep, goat, antelope and deer.

Monnig, 1928 (4), uses the name *T. axei* when referring to the parasite of the sheep, goat and horse, so that he accepts the statement of Le Roux and the other writers referred to in that paper.

Baylis, 1929 (5), says of *T. axei*: "This species bears a very close resemblance to *T. extenuatus*, of which possibly it is really a variety." He, however, uses the name *T. extenuatus* when referring to the parasite of the ox, sheep, and goat.

Some while ago I examined and measured, and also drew, the alem bursa, spicules, etc., of specimens of a Trichostrongylus collected in abundance from the stomach of a horse in Taiping, F.M.S., in 1927. After conclusion of my work I happened on Le Roux's statement(2) mentioned above, and on comparison of my drawings with the figures of *T. extenuatus* in Ransom, 1911 (6), I found them to be identical. As at the time I made my drawings I had not noted the work covered by my references 2, 4, and 5, I could not possibly have been misled by any previous impression. I have therefore pleasure in confirming Mr. Le Roux's statement; which, I should point out, he does not claim originality for. He, however, did examine material, previous authors not making it clear upon what grounds they adjudged the two species to be the same. As *T. axei* is the older name, *T. extenuatus* must drop out as a synonym. The survival of the latter name, however, in as late and important a publication as that of Baylis, 1929, makes it apparent that attention requires to be re-drawn to this fact.

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BRUCELLA ABORTUS IN RELATION TO MAN IN IRELAND.

By JOSEPH W. BIGGER, D.Sc., F.R.C.P.I.
Professor of Bacteriology and Hygiene, Dublin University.

In view of the considerable space lately devoted in current medical literature to undulant fever due to *Br. abortus*, the time seems opportune for a consideration of the question as it affects Ireland.

It might first be well to discuss briefly the historical aspect of the subject. For many years a form of fever, described as Malta fever, Mediterranean fever, or Gibraltar fever, was prevalent in various countries, particularly those on the shores of the Mediterranean Sea. Since such local terminologies are confusing, and, further, affect the susceptibilities of the inhabitants of the countries concerned, it is advisable to use the more appropriate term, undulant fever, for them, as was first suggested by Hughes.

The causal organism was discovered in Malta by Bruce in 1887. This organism, first called *Micrococcus melitensis*, and later *Bacillus melitensis*, is now usually known as *Brucella* (*Br.*) *melitensis*, in honour of its discoverer. The method of infection remained a mystery until 1905, when from two independent sources fresh light was thrown on the problem. One of these was the work of the Commission in Malta, and the other was an outbreak of undulant fever on board a vessel carrying goats from Malta to America. The milk of these goats had been used during the voyage, and, on arrival in America, it was discovered that many of them were excreting *Br. melitensis* in their milk. Investigation in Malta revealed the fact that the milk of a large proportion of goats in the island contained the organism, and it was obvious that, while undulant fever might be contracted by contact with the organism or in other ways, the usual method of infection was by drinking the milk of infected goats.

In 1897, Bang discovered that the organism now known as *Br. abortus* was the cause of epizoötic abortion in cattle. Evans, in 1918, pointed out the close microscopic, cultural and serological similarity between *Br. Melitensis* and *Br. abortus*, but it was not until 1922 that Bevan, struck by the occurrence of cases of undulant fever in Southern Rhodesia among persons who had had no contact with goats or their milk, suggested that *Br. abortus* might be a cause of undulant fever in man. Keefer, in 1924, described the first human case of undulant fever in which *Br. abortus* was proved to be causal, and since that time some thousands of human cases have been described in America, and considerable numbers in other countries, including Great Britain.

Denmark, with a population of three and a-half millions, has about 500 cases of undulant fever each year ; while in Ireland, with a population of over four millions, only three cases have been described —two in Northern Ireland,[1] and one in the Irish Free State.[2] The comparitive rarity of the disease in this country demands attention, but first it is necessary to consider the method of spread of the disease to man. On this point there is general agreement that infection may occur by handling infected animals, but that the majority of

cases are due to the drinking of milk containing the bacilli. Cows infected with *Br. abortus* usually harbour the organisms in their bodies for a long period. In the earlier stages abortion results, but later the cows become carriers, capable of bearing mature calves, but continuing to excrete bacilli in their milk. By such milk, drunk in its raw state, the infection is spread to man. Two strains of *Br. abortus* can be recognised—bovine and porcine—the latter of which normally causes abortion in sows, but can also affect cows. The differentiation of the two is not easy, but one point of distinction is the greater virulence of the porcine strain for guinea-pigs. It has been suggested in America that the porcine strain, whether direct from pigs, or indirectly by way of cows, is responsible for a considerable part of human infections. This is probably true, and suggests the further possibility that among bovine strains may be some of low, and some of high virulence for man, human infections resulting chiefly or entirely from the latter.

It is well known that epizoötic abortion is a common disease among cows in this country. Norris,[3] in 1928, examined 100 milk samples, each derived from an average of eleven cows, and found eighteen to contain *Br. abortus*. These milks came chiefly from Munster, in which province epizoötic abortion is particularly prevalent. This figure, the only one available for the percentage of mixed milks containing *Br. abortus* in Ireland, is fairly similar to that obtained in America, Australia, Denmark, England and elsewhere, showing that Ireland, like other countries, has a considerable proportion of cows excreting *Br. abortus* in their milk.

Since, in Ireland, the greater part of the milk is drunk raw, one would, under these circumstances, expect a high incidence of undulant fever to occur in this country. Various explanations of the fewness of the recorded cases might be suggested: (1) Lack of sufficient search for cases; (2) unusual human resistance in Ireland against *Br. abortus*; (3) low virulence for man of the Irish strains of *Br. abortus*.

A number of skilled clinicians are on the watch for the disease, and in my laboratory, as I believe in others, all bloods sent for Widal test are also tested against *Br. abortus*, and yet only the two cases have been found. I am, therefore, of the opinion that if undulant fever were as common in Ireland as it appears to be elsewhere, more cases would have been diagnosed. Still, the possibility of the disease should be borne in mind by every physician in charge of a case of fever of uncertain ætiology, and an attempt should be made to arrive at a certain diagnosis by agglutination tests and blood culture.

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The second possibility appears to be unlikely. It is worth remark, however, that cases occur chiefly between the ages of fifteen and forty-five, and that only a very small number have been found in children under six years of age. From this it would appear that there may be an inherited immunity in young children. It is possible, although not particularly probable, that the almost universal use of raw milk in Ireland may lead to the development of an active immunity in the growing child before this inherited immunity has disappeared.

The most probable explanation for the rarity of undulant fever in Ireland is that the virulence for man of the organism present in this country in cows is low. This is supported to some extent by the observation of Mr. J. H. Norris, F.R.C.V.S., in a personal communication to the writer, that the porcine strain has never been found in Ireland, and that the strains isolated are of low virulence for guineapigs.

A number of observers in various countries have found antibodies, chiefly agglutinins, against *Br. abortus* in the sera of individuals who have consumed raw milk containing the organisms, and who have never suffered from undulant fever. It has been objected that *Br. abortus* agglutinins are commonly present in the milk of cows containing *Br. abortus*, and that the agglutinin found in human blood may be due to its absorption from the alimentary tract. The weight of evidence is entirely against the possibility of such passage of antibodies through the adult alimentary mucous membrane, and the work of Carpenter, Boak, and Chapman appears to prove that the consumption of raw milk containing *Br. abortus* and its agglutinin results in the appearance of agglutinin in the blood, but that after the consumption of the same milk which has been pasteurised, so destroying the bacilli, but leaving the agglutinin intact, no agglutinin appears in the blood. The presence then of *Br. abortus* agglutinin in the blood of an individual seems to prove that the body of that individual has been invaded by living *Br. abortus* without of necessity infection resulting.

During the year 1930, the blood sera of 500 persons were tested to determine the presence or absence of agglutinins for *Br. abortus*. The sera were all submitted to my laboratory for Wassermann test, mostly from doctors and hospitals in Dublin, but some from other parts of Ireland. Since Dublin acts as a hospital centre for a large part of Ireland, it is probable that the sample is fairly representative of the country as a whole : it is known that thirty of the bloods came from Cork.

The suspension of *Br. abortus* used in this work was prepared from a strain isolated from a human case (No. 3), which was obtained

from Professor J. H. Damon, of the School of Hygiene, Johns Hopkins University, Baltimore. Forty-eight hour agar cultures were washed off in saline, and the organisms killed by heating for 45 minutes at 55° C. After dilution with saline to suitable density, 0.4 per cent. of phenol was added. When required for use this stock culture was diluted with equal parts of saline, so producing a suspension containing about 500 million bacilli per c.c. The preliminary test was done by mixing one drop of the serum (previously heated to 55° C. for thirty minutes) with nineteen drops of the dilute suspension. The test was done in dwarf conical-ended tubes, which were immersed to one-half the height of the column of fluid in a water bath maintained at 52° C. After four hours at this temperature, the tubes were removed and left overnight (eighteen hours) at air temperature, when results were read, using a × 6 lens. Sera giving a positive result were re-tested, using the usual Dreyer system of dilutions, but omitting the first tube. For this the stock suspension was diluted in the proportion of four parts of suspension to one of saline, so giving approximately the same density of suspension as in the earlier test. The methods of incubation and reading were the same as before. The titres recorded for the sera were: 1/20, 1/50, 1/125, and 1/250. The scale of recording results was as follows: + agglutination visible only with lens; ++ agglutination visible with naked eye; +++ agglutination with complete sedimentation. Exactly 100 of the sera tested showed some degree of agglutination, 400 giving a negative result at 1/20. In the following table the results are summarised:

Number of Sera	1/20	1/50	1/125	1/250
400	—	—	—	—
53	+	—	—	—
25	++	—	—	—
7	++	+	—	—
1	++	++	—	—
4	+++	++	—	—
7	++	++	+	—
1	+++	++	+	—
1	+++	++	++	—
1	+++	+++	++	—

Twenty per cent. of the sera had a titre of 1/20 or higher, 4.4 per cent. 1/50 or higher, and 2.0 per cent. 1/125. No serum had a titre of 1/250.

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It is realised that by using only a dilution of 1/20 in the preliminary test, certain positive sera may have been missed, owing to the occurrence of inhibition zones, and, further, that higher titres might have been obtained if the sera had not been heated to 55° C. before testing, and if the test had been carried out at a lower temperature than 52° C. The results may, therefore, be taken as possibly too low, certainly not as too high.

These results may be compared with those obtained elsewhere, where, for the most part, a lower percentage of positive results have been obtained. Carpenter, Boak, and Chapman, in Syracuse, New York, using similar material, found 7.3 per cent. of sera tested to have a titre of 1/15 or higher, 1.2 per cent. 1/45 or higher, and 0.3 per cent. 1/135 or higher. In Syracuse a considerable amount of raw milk is drunk, but probably much less than in Dublin. In New York City, where almost all milk is pasteurised, they found only 2.4 per cent. of sera to show agglutinin for *Br. abortus*, and in none did the titre exceed 1/45. In Denmark, Madsen[5] found 10 per cent. of sera to contain *Br. abortus* agglutinin. Harrison and Wilson,[6] in Manchester, found 5.5 per cent. of positive results with titres of 1/10 or more, and 3.9 per cent. positive at 1/20 or over.

In my series, 57 per cent. of the individuals from whom the sera were derived were males, while among those showing positive results, 53 per cent. were males. This indicates no significant difference between the sexes in the occurrence of *Br. abortus* agglutinins. In Harrison and Wilson's series positive results were twice as frequent among females as males.

There can be little doubt that the 20 per cent. of persons in whose sera *Br. abortus* agglutinins have been found have suffered invasion by the organism. Whether in some an infection had at one time occurred cannot be determined. It was not found possible to investigate the positive cases clinically to determine whether an actual infection was present at the time when the serum acted positively, but, from the information available, there is no reason to believe that they showed any evidence of undulant fever.

Since the work here recorded is being continued, this is to be regarded merely as a preliminary survey of the field. It appears to be established that the occurrence of epizoötic abortion is about as common in Ireland as elsewhere, and this work proves that a considerable proportion of human beings show evidence of invasion by *Br. abortus*, as is to be expected in a raw-milk drinking community. Whether the opinion that undulant fever is really a rare condition in Ireland is sound, can only be determined by further clinical observation

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and laboratory investigation. If this opinion is well founded, it may then be possible to test the truth of the hypothesis here suggested, that the strain of *Br. abortus* affecting Irish cows has a very low degree of virulence for human beings.

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Clinical Articles

A Report on the Chemical Analysis of Calculus taken out on Post-Mortem from the Intestines of a Polo Pony Mare.

By D. S. LAUD, G.B.V.C., F.Z.S.

Superintendent, Municipal Gardens, Bombay.

THERE are two kinds of calculi, as described by some authors, which cause obstruction of the intestines, *viz.*: (*a*) true calculi; and (*b*) false calculi, or hair balls. The difference consists in the composition of the calculus causing the obstruction, but in cases where the false calculus enlarges in size, similar symptoms are produced. True calculi are also termed enteroliths or benzoars. They consist of a central nucleus, which may be of foreign body, like a nail, pebble, particle of sand, or a portion of hard and thickened mucus, around which in concentric layers are arranged salts of ammonia, magnesium phosphate and lime, phosphates of lime and magnesia, a small amount of silica, mucus, and epithelium, and organic matters derived from the ingesta. They are heavier than the false calculi, and assume various shapes, form, and size.

False calculi—ægagropiles or hair, or oat hair balls—consist of fine vegetable hairs surrounding the grains of oats, barley, and other grains, and are also derived from the animals themselves by their licking one another, especially when horses have depraved appetites.

Dr. B. D. Khote, L.R.C.P., L.R.F.P. & S., chief medical officer of Rajpipla State, in Gujerat, Bombay Presidency, sent me a specimen of the calculus, with the following note: " Pathological specimen

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taken out from the horse's intestines after post-mortem. A polo pony, mare, aged fourteen, last week had an attack of colic, and died after fourteen hours. The mass was removed from the floating colon which had twisted on its axis." The calculus was rounded in form, and weighed about twelve ounces, and when broken, vegetable fibres with particles of hay could be seen therein.

The specimen was sent to Colonel F. P. Mackie, I.M.S., director of the Haffkine Institute in Bombay, who kindly had it examined, and sent me the following report :—

Qualitative Analysis.—Chlorides, sulphates, oxalates, bile salts, and bile pigments were found present in slight traces. Fat and glucose were present in slightly greater amounts ; the quantities present were too small for quantitative analysis. Calcium was specially tested for, and found absent.

Quantitative Analysis.	Percentages.
Combustible organic matter—NH_3	50.45
Silica	17.50
P_2O_5	12.70
Al_2O_3	10.44
Fe_2O_3	0.72
MgO	7.73
Total ...	99.54

My best thanks are due to Colonel F. P. Mackie and his staff for examining the calculus and sending the report. I am recording this case, as it will prove, I think, of great interest to the veterinarian.

Cerebral Hæmorrhage in a Cow.

By FRANK CHAMBERS, F.R.C.V.S.
Wolverhampton.

In September, 1930, a half-bred shorthorn cow was purchased as a newly-calved cow in the open market. The day after arriving home the owner noticed that there was a purulent discharge from the vulva, and the cow was not eating very well. I was asked to examine her, and found that the temperature was 105 F., and there was occasional straining. On manual examination per vagina, it was found that the os uteri was dilated, and a fair amount of afterbirth was present. As much as possible was removed, and two pessaries inserted into the uterus. The cow was first seen on September 26th, and by October 8th she had "turned the corner," and was beginning to pick up. I did not see the cow again until May 28th of this year,

when my advice was asked on account of the sudden appearance of a huge " swelling " which extended from the lower portion of the vulva right down to the udder. The swelling was obviously a hæmatoma. No mark or abrasion could be seen, and it was surmised that the cow had been injured by the horn of another animal. The hæmatoma was opened on June 1st, and about two bucketfuls of clots were removed. The cavity was syringed out daily with a mild antiseptic, but it was obvious that most of the skin over the hæmatoma was dead, and in due course would slough away. This is what did happen, and as a large unsightly mass of skin was hanging, I cut it away from its attached portions at the dorsal position. Although the portion of

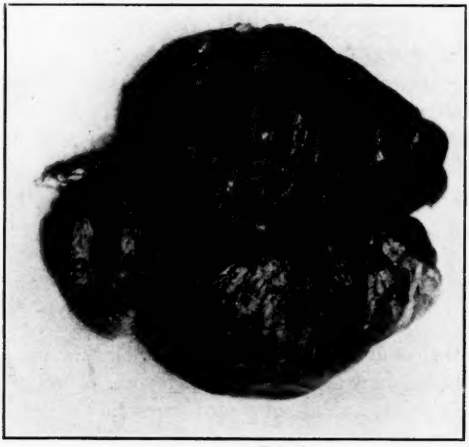

FIG. 1.—Dorsal surface of brain showing hæmorrhage extending over whole surface of the left cerebrum.

skin that I cut felt hard and leathery, there was severe hæmorrhage afterwards which took a lot of controlling. The vessels in the skin could not be picked up owing to the hard dense nature of their surroundings. The wound got less and less, until it only measured about eight inches in diameter. On June 6th, the cow was " bulling," and in attempting to ride another cow, when they were being driven into the byre, she slipped and hit the left side of her head a very severe blow on the edge of the gutter. She got up again, and walked with difficulty into her stall. I saw her later in the day, and on liberating her found that she was quite blind, and moved always to the right side. By holding the left horn, I steered her into a loose box, where she appeared quite comfortable. Unfortunately, she died during the

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night. As it was obvious that there was a cerebral hæmorrhage, I obtained the head and made a post-mortem examination. There was a hæmorrhage into the frontal air sinus, and the left horn core was damaged. On opening the cranium, there was visible a generalised hæmorrhage under the meninges covering the left cerebrum. (Fig. 1). The brain was sent to Mr. P. Blount, who made a detailed examination, and reported to me as follows :

Severe hæmorrhage is evident on practically the whole of the dorsal aspect of the left cerebrum, more particularly towards the occipital (posterior) pole where the hæmorrhage extends ventrally and laterally. Some hæmorrhage is also seen on the lateral aspect of the left lateral lobe of the cerebellum (about the suprasylvian

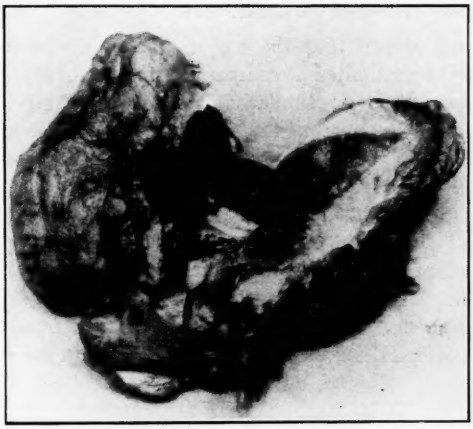

FIG. 2.—Ventral surface of brain cut open, showing clot in the left ventricles.

fissure). The extravasation is best seen under the *pia mater*, where it has filled many of the smaller gyri and sulci. There is slight hæmorrhage near the frontal (anterior) pole (lobe) of the right cerebral hemisphere.

Ventrally, a large blood clot is observable in region of the optic chiasma. It extends upwards and backwards, occupying portions of the left ventricles in both hemispheres. In the right it lies parallel to the anterior border of the hippocampus upon which it rests. Anteriorly, it rests on the dorsal aspect of the striate body, where it unites with the hæmorrhagic mass of the left cerebrum. This mass extends laterally from the level of the choroid plexus into the main cerebral substance as an egg-shaped solidified blood clot; the sur-

rounding brain tissue is degenerate, soft, mushy, and strawberry tinted. An additional clot is seen extending posteriorly over the Hippocampus in much the same fashion as described above for the opposite hemisphere. The source of blood appears to be from the region of the bifurcation of the basilar artery, but it is difficult to dissect satisfactorily.

The weight of the whole blood clot is about 30 grammes (one ounce).

NOTE.—Removal of the cerebrum fails to affect teleosteans, and has little effect on many of the lower animals apparently.

Although electrical stimulation of the cerebral cortex (certain areas only) gives movement of limb, etc., removal of cortical areas does not cause permanent paralysis.

Arloing has shown that the motor area in the horse's cerebral hemispheres is very limited as compared with that of man, the higher apes, and even the dog; similarly, Simpson and King have shown that in the sheep, removal of the motor areas does not lead to limb paralysis. Clinically it is known that horses may possess tumours the size of a hen's egg in the lateral ventricle, and yet exhibit no disturbance (Smith), but it is to be realised that such abnormalities are produced slowly, and therefore it is presumably possible for tissues to adapt themselves to the changes, whereas with severe internal hæmorrhage, the resultant clot immediately causes destruction of nerve paths, etc. Blindness may have resulted from destruction either of the occipital lobes or from interference with the optic tracts.

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